INDOOR AIR QUALITY ASSESSMENT

Bryantville Elementary School
29 Gurney Drive
Pembroke, MA

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
October 2017

Background

Building:	Bryantville Elementary School (BES)
Address:	29 Gurney Drive, Pembroke, MA
Assessment Requested by:	Justin J. Domingos, Director of Athletics/Facilities, Pembroke Public Schools
Reason for Request:	General indoor air quality (IAQ) concerns
Date of Assessment:	October 6, 2017
Massachusetts Department of Public Health/Bureau of Environmental Health (MDPH/BEH) Staff Conducting Assessment:	Mike Feeney, Director and Cory Holmes, Environmental Analyst, IAQ Program
Date of Building Construction:	Late 1960's, renovated in 1999
Building Description:	Brick and concrete construction with interior courtyards
Building Population:	Approximately 500 students in grades Pre-K through 6 with a staff of approximately 65
Windows:	Openable

IAQ Testing Results

Please refer to the IAQ Manual for methods, sampling procedures, and interpretation of results (MDPH, 2015). The following is a summary of indoor air testing results (Table 1).

- ***Carbon dioxide levels*** were below 800 parts per million (ppm) 48 of 50 areas tested, indicating adequate air exchange throughout the building, however some areas were empty, which can reduce carbon dioxide levels.
- ***Temperature*** was within the recommended range of 70°F to 78°F the day of assessment.
- ***Relative humidity*** was within the recommended range of 40 to 60% in all areas the day of assessment.
- ***Carbon monoxide*** levels were non-detectable in all areas tested.
- **Fine particulate matter (PM2.5)** concentrations measured were below the NAAQS limit of 35 $\mu g/m^3$ in all areas tested.

Ventilation

A heating, ventilating and air conditioning (HVAC) system has several functions. First it provides heating and, if equipped, cooling. Second, it is a source of fresh air. Finally, an HVAC system will dilute and remove normally occurring indoor environmental pollutants by not only introducing fresh air, but by filtering the airstream and ejecting stale air to the outdoors via exhaust ventilation. Even if an HVAC system is operating as designed, point sources of respiratory irritation may exist and cause symptoms in sensitive individuals.

Fresh air is provided by a combination of unit ventilators (univents) located in individual classrooms (Picture 1) and air handling units (AHUs; Picture 2), which serve central areas such as the gym, library and office areas. The unit ventilators draw fresh air through a vent on the exterior wall (Picture 3). Air is mixed with return air from the room, filtered, heated (if needed) and delivered to the room (Figure 1). Air from the AHUs is filtered, heated or cooled as needed, and delivered to rooms via ducted supply vents (Picture 4).

It was reported that univents operate under an automated/energy efficiency management system and cycle off/on according to the set point of the thermostat, which deactivates the HVAC system when it reaches a preset temperature, therefore, no mechanical ventilation is provided until the thermostat reactivates the system. To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate *continuously* during periods of occupancy. In addition, many univents were obstructed by items placed on top or in front (Pictures 5 and 6). Both the top and the vent at the bottom need to be kept clear of obstructions for the units to operate as designed.

Air is exhausted from ceiling-mounted exhaust vents on the opposite side of the room, in some cases near classroom doors (Picture 7). Note that when classroom doors are open, exhaust vents will tend to pull hallway air into the classroom instead of removing stale air/pollutants from the room and out the building.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air while removing stale air from a room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). It is unknown the last time these systems were balanced.

Microbial/Moisture Concerns

Water-damaged ceiling tiles were observed in a few areas (Picture 8; Table 1), which indicate leaks from the building envelope or plumbing system. These tiles should be replaced after the leak is found and repaired. It was reported that roof repairs had recently been conducted to prevent further leaks.

In order to allow for water to drain from the exterior brick wall system, a series of weep holes is customarily installed at or near the foundation slab/exterior wall system junction (Figure 2). Weep holes allow for accumulated water to drain from a wall system (Dalzell, 1955). Failure to install weep holes in brickwork or burial of weep holes below grade will allow water to accumulate in the base of walls, resulting in seepage and possible moistening of building components (Figure 3).

The exterior of the BES consists of a traditional red brick exterior wall. An examination of brick walls was conducted (along the exterior and in courtyards) to identify the location and condition of weep holes. Weep holes were found approximately at the slab level. Of note is that many weep holes were blocked with debris (Picture 9) or buried, which prevents water drainage from the exterior wall system.

The school is built around four courtyards which are severely overgrown with trees, shrubbery and other plants (Pictures 10 and 11). Trees were also observed overhanging the roof in some areas (Picture 12). These conditions can lead to deterioration of the building envelope due to root infiltration and dampness against exterior walls/foundation. Plants can also be a source of moisture, debris and pollen drawn into air intakes. Plants/trees should be trimmed away from the building and from overhanging the roof to prevent clogging of roof drains/gutters.

Indoor plants were observed in a few areas (Table 1). Plants can be a source of pollen and mold, which can be respiratory irritants to some individuals. Plants should be properly maintained and equipped with drip pans and should be located away from air diffusers to prevent the aerosolization of dirt, pollen and mold.

Light could be seen beneath the exterior door to entrance #3 (Picture 13). The exterior was examined and found to have a missing/damaged door sweep (Picture 14), which can provide a pathway for moisture, drafts and or pests into the building.

Other IAQ Evaluations

Exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat, and/or respiratory irritation in some sensitive individuals. To determine if VOCs were present, BEH/IAQ staff examined rooms for products containing VOCs. BEH/IAQ staff noted hand sanitizers, cleaners/spray bottles and dry erase materials in use within the building. All of these products have the potential to be irritants to the eyes, nose, throat, and respiratory system of sensitive individuals. In addition, spray bottles/cleaning products should be kept out of reach of children.

In a few areas, tennis balls had been sliced open and placed on chair footings to reduce noise (Picture 15). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and lead to off-gassing of VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997; NIOSH, 1998).

Many classrooms had personal fans. Some of these had dusty blades (Picture 16; Table 1). Some supply diffusers (Picture 4) and exhaust vents were also observed to be dusty. This dust can be reaerosolized when the equipment is activated. In many areas, items, including books, papers, toys and decorative items were observed on floors, windowsills, tabletops, counters, bookcases, and desks (Picture 17; Table 1), which can make it more difficult for custodial staff to clean.

Univents have open grills along the top to allow airflow that tend to accumulated dust and debris. Cleaning the grills/interior of the units out regularly is recommended (e.g., during filter changes). Window-mounted air conditioners in classrooms contain filters that should be cleaned or changed regularly in accordance with manufacturer's instructions to prevent the build-up of dust and debris.

Many classrooms/areas had carpeting. Carpeting should be cleaned annually or semi-annually in soiled high traffic areas as per the recommendations of the Institute of Inspection, Cleaning and Restoration Certification (IICRC, 2012). Many classrooms had area rugs, which should also be cleaned regularly and discarded when too worn out or soiled to be cleaned.

Note that the Environmental Protection Agency (EPA) conducted a National School Radon Survey in which it discovered nearly one in five schools had "…at least one frequently occupied ground contact room with short-term radon levels above 4 [picocuries per liter] pCi/L" (US EPA 1993). The BEH/IAQ Program therefore recommends that every school be tested for radon, and that this testing be conducted during the heating season while school is in session in a manner consistent with USEPA radon testing guidelines. Radon measurement specialists and other information can be found at www.nrsb.org and http://aarst-nrpp.com/wp, with additional information at: http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/exposure-topics/iaq/radon.

Conclusions/Recommendations

The following recommendations are made to assist in improving IAQ:

1. Operate all supply and exhaust ventilation equipment continuously (vs. cycling/thermostat setpoint) during occupied periods.
2. Use openable windows to supplement fresh air during temperate weather. Ensure all windows are tightly closed at the end of the day.
3. Remove items and furniture blocking univents both on top and along the front.
4. Check exhaust vents for draw periodically and repair any non-operating vents.
5. Close classroom doors to facilitate exhaust function.
6. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Ensure roof and plumbing leaks are repaired and replace water-damaged ceiling tiles.
9. Ensure plants, trees and shrubs are located at least five feet away from exterior walls/foundation of the building in both courtyards and around the exterior of the building.

10. Remove blockages from all weep holes and clear obstructions to walls to maximize water drainage from exterior wall systems.
11. Properly maintain plants, including drip pans, to prevent water damage to porous materials. Plants should also be located away from air diffusers to prevent the aerosolization of dirt, pollen, and mold.
12. Replace missing/damaged sweeps on exterior doors. Ensure tightness by monitoring for light penetration around doors.
13. Reduce use of products and equipment that create VOCs; only use in well-ventilated areas.
14. Keep spray bottles/cleaning products out of the reach of children (e.g., in cabinets over sinks).
15. Replace tennis balls on chair footings with latex-free glides.
16. Continue to change filters for HVAC equipment 2-4 times a year. The MDPH recommends using pleated filters of Minimum Efficiency Reporting Value (MERV) of 8, which are adequate in filtering out pollen and mold spores (ASHRAE, 2012), if these can be used with current equipment.
17. Regularly clean/vacuum univent cabinets, supply/return vents and fans to avoid aerosolizing accumulated particulate matter. Consider using compressed air to loosen/remove accumulated dust/debris in hard to access univent grills/cabinets, and then vacuum with a HEPA vacuum cleaner.
18. Clean window-mounted air conditioner filters prior to the start of the cooling season and according to the manufacturer's instructions.
19. Consider reducing the amount of items stored in classrooms to make cleaning easier. Periodically move items to clean flat surfaces.
20. Clean carpeting annually (or semi-annually in soiled high traffic areas) as per the recommendations of the Institute of Inspection, Cleaning and Restoration Certification (IICRC).
21. The school should be tested for radon by a certified radon measurement specialist during the heating season when school is in session. Radon measurement specialists and other information can be found at: www.nrsb.org, and http://aarst-nrpp.com/wp.

22. Consider adopting the US EPA (2000) document, “Tools for Schools”, as an instrument for maintaining a good IAQ environment in the building available at: http://www.epa.gov/iaq/schools/index.html.
23. Refer to resource manual and other related IAQ documents located on the MDPH’s website for further building-wide evaluations and advice on maintaining public buildings. These documents are available at: http://mass.gov/dph/iaq.

References

ASHRAE. 2012. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 52.2-2012 -- Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI Approved).

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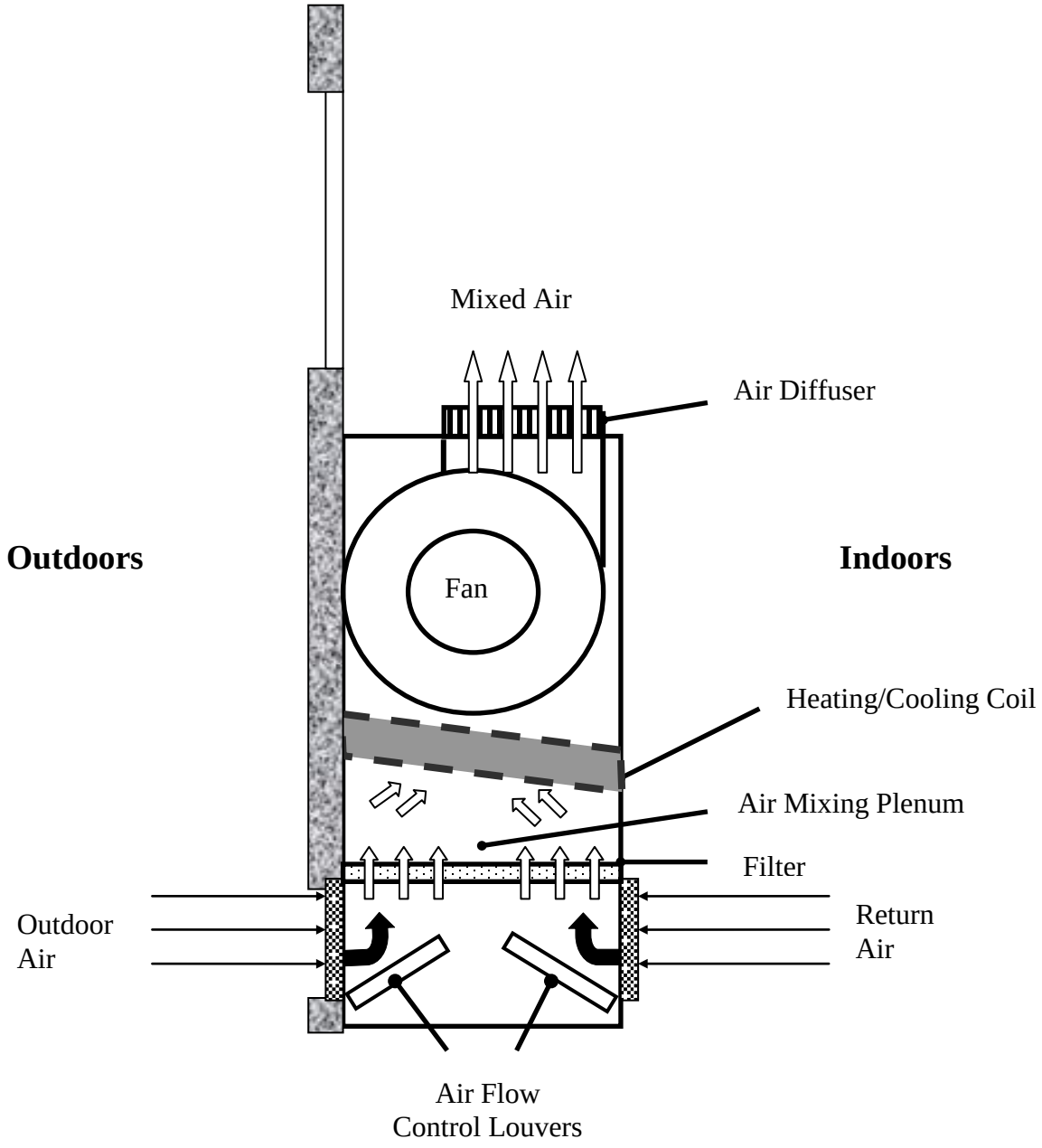
US EPA. 2000. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/index.html.

Figure 1

Unit Ventilator (univent)



Air Flow

= Fresh air return
= Mixed air

Figure 2

Drainage Plane Function: Weep Holes Drain Water from the Wall System to Prevent Moisture Penetration into the Interior

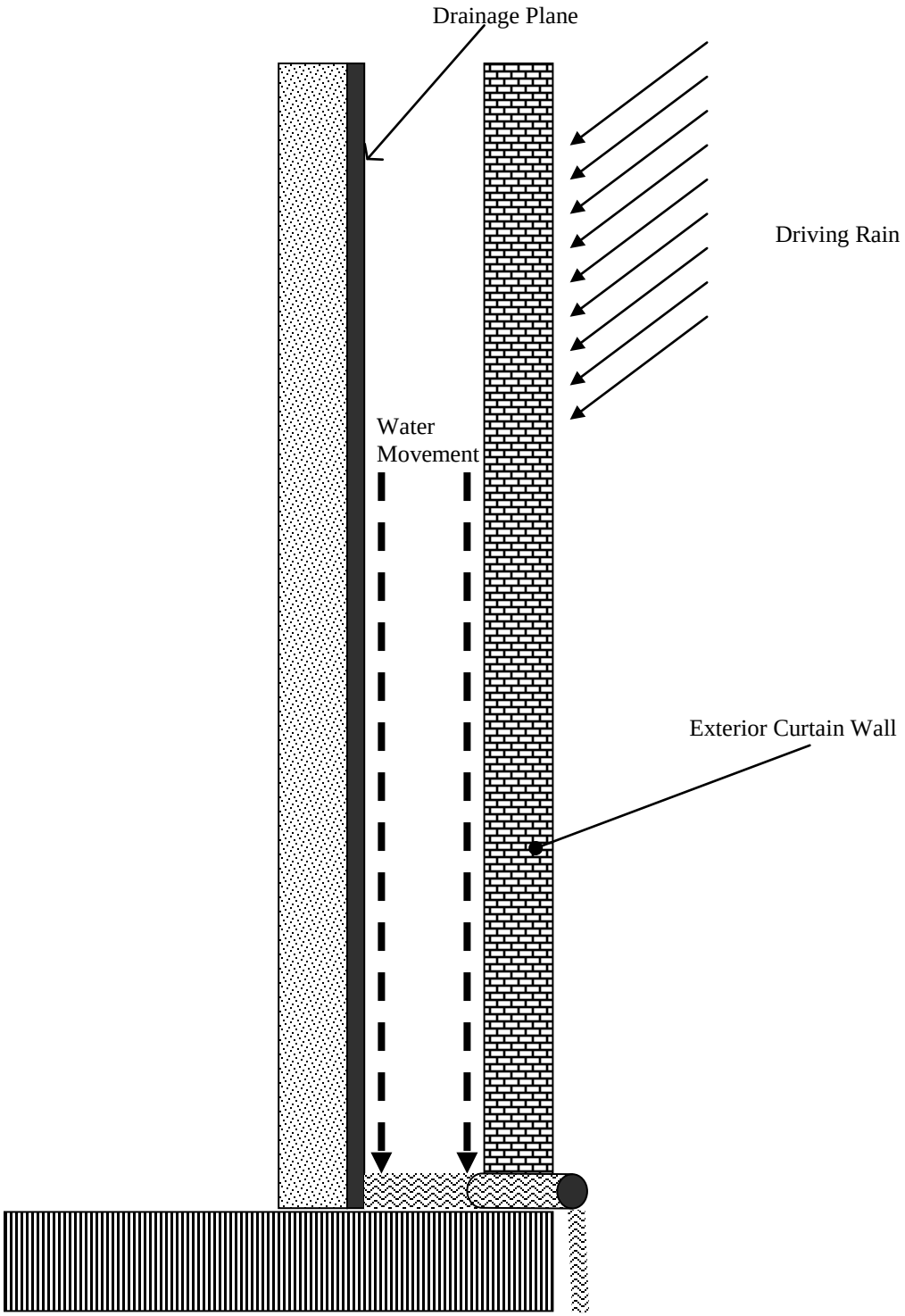
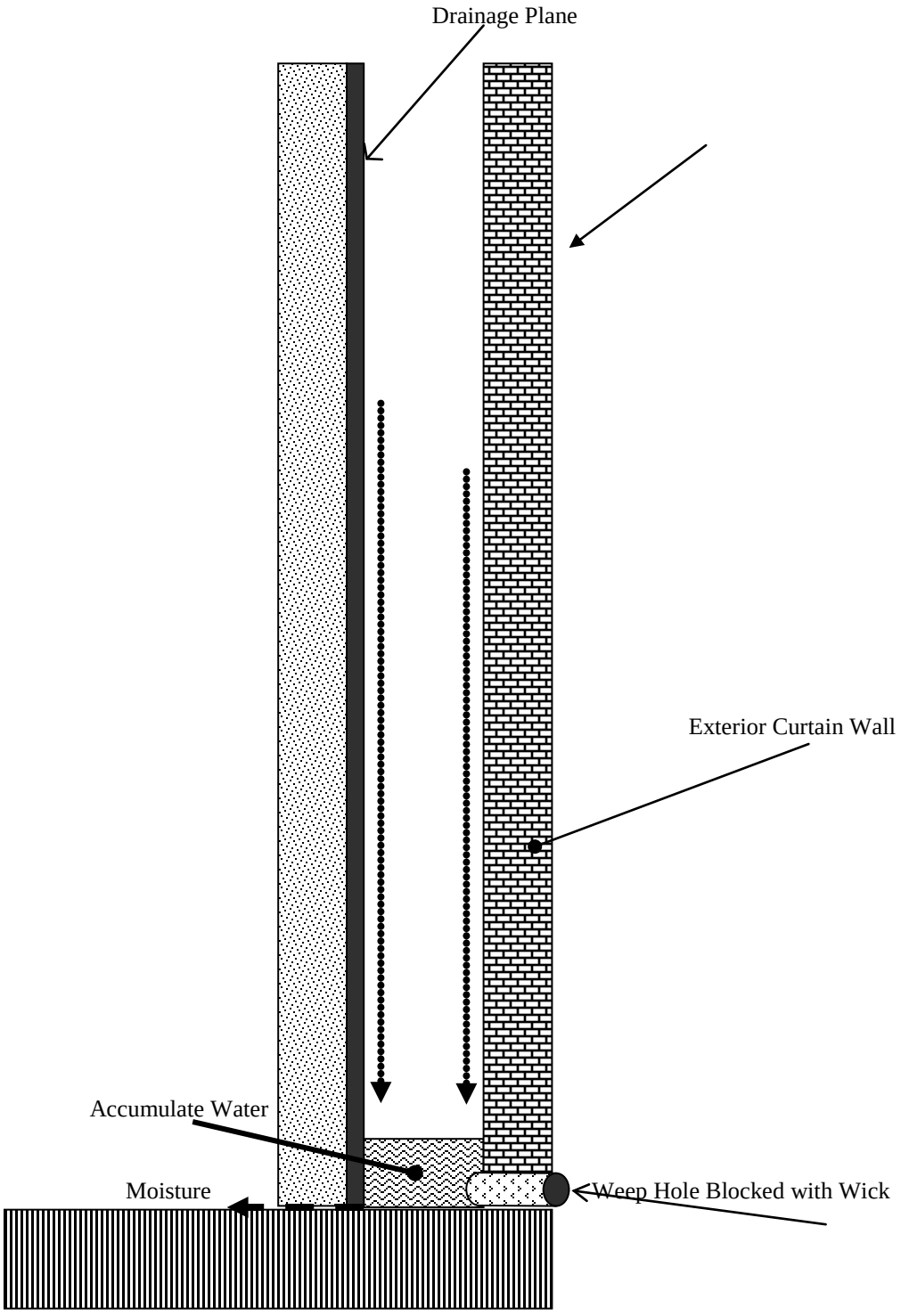


Figure 3

Blocked Weep Hole: Water Accumulates in the Drainage Plane



Picture 1

Classroom univent

Picture 2

Rooftop air handling unit

Picture 3

Univent fresh air intake, note plants/shrubbery

Picture 4

Ceiling-mounted supply diffuser, note dust/debris on louvers

Picture 5

Items on univent/front of return vent (bottom/front)

Picture 6

Items on top of univent air diffuser

Picture 7

Ceiling-mounted exhaust vent near open classroom door

Picture 8

Water-damaged ceiling tile

Picture 9

Blocked weep hole

Picture 10

Courtyard overgrown with plants/shrubbery

Picture 11

Courtyard overgrown with trees, plants and shrubbery

Picture 12

Trees overhanging roof

Picture 13

Light penetrating beneath doorway #3

Picture 14

Missing/damaged door sweep

Picture 15

Tennis balls on chair legs

Picture 16

Accumulated dust/debris on fan blades

Picture 17

Accumulated items on flat surfaces

Location: Bryantville Elementary School

Address: 29 Gurney Drive, Pembroke, MA

Indoor Air Results

Date: 10/6/2017

Table 1

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m^3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
Background	391	ND	69	63	7					Warm, scattered clouds
114	661	ND	77	53	8	18	Y/3	Y	Y	DO, area rug, items on/front of UV, PF-dusty
116	631	ND	78	52	8	23	Y	Y	Y	PF, HS, area rug
117	433	ND	75	51	7	0	Y/3	Y	Y	DO, TB, PF
119 OT/PT	556	ND	76	49	6	1	Y	Y	Y	Window AC, HS, DO
121	691	ND	76	53	9	20	Y/1	Y	Y	DO, items on UV, PF, area rug
122	1034	ND	78	59	9	21	Y	Y	Y	DO, area rug, HS
124	746	ND	72	58	7	21	Y	Y	Y	DO, TB, PF-dusty, items on/front of UV, HS
126	765	ND	77	59	8	21	Y	Y	Y	PF, DO, HS
127	486	ND	76	54	8	1	Y/1	Y	Y	15 occupants gone ~40 mins, PF, HS, plants, DO

ppm = parts per million
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ND = non-detect
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DO = door open
HS = hand sanitizer
PF = personal fan
TB = tennis balls
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WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 800 ppm = preferable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location: Bryantville Elementary School **Indoor Air Results**

Address: 29 Gurney Drive, Pembroke, MA

Table 1 (continued)

Date: 10/6/2017

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
129	478	ND	75	52	7	0	Y Open	Y	Y	TB
131	469	ND	75	51	6	0	Y	Y	Y	
133	584	ND	75	54	7	0	Y	Y	Y	WD CT
136	792	ND	75	58	14	0	Y	Y	Y	Items on UV
138	574	ND	76	57	14	0	Y	Y	Y	
139	534	ND	74	53	9	0	Y	Y	Y	
142	546	ND	73	59	7	17	Y	Y	Y	HS
Library	785	ND	71	44	4	15	Y	Y	Y	Wall to wall carpet, HS, dust/debris on vents
148	540	ND	73	59	9	0	Y/1	Y	Y	DO, wall to wall carpet
152	590	ND	73	60	10	0	Y	Y Off	Y	Wall to wall carpet, PF-dusty, HS, DO, exhaust near open hallway door

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								Intake	Exhaust	
162	596	ND	76	52	9	20	Y	Y	Y	
167	452	ND	76	52	6	0	Y Open	Y	Y	Shrubs in close proximity to UV air intakes
168	509	ND	74	57	6		Y	Y	Y	
169	545	ND	76	52	6	14	Y Open	Y	Y	Shrubs in close proximity to UV air intakes
190	475	ND	76	49	5	18	Y	Y	Y	Shrubs in close proximity to UV air intakes, AD
191	504	ND	74	55	8	1	Y	Y	Y	Items on/front of UV, DO, HS
192	647	ND	71	48	8	15	Y	Y	Y	AD, window AC, PF-dusty, spray bottles on countertop, HS
194 Storage	446	ND	76	51	9	0	Y	Y	Y	Classroom furniture/items
197	605	ND	76	54	7	21	Y/5	Y	Y	DO, PF, HS, items on UV

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								Intake	Exhaust	
198	613	ND	77	51	8	20	Y	Y	Y	DO, PF, HS, area rug
Teacher's Planning	680	ND	74	56	5	0	Y	Y	Y	Wall to wall carpet, shrubs in close proximity to UV air intakes
Main Office	683	ND	74	47	5	2	Y	Y	Y	Wall to wall carpet, HS, photo copier, plant
Principal's Office	643	ND	73	47	5	0	Y	Y	Y	HS, wall to wall carpet, DO, plants
Cafetorium	580	ND	77	53	9	90	Y	Y	Y	Dust/debris on vents, ceiling fans-on
Nurse	426	ND	73	49	8	2	Y/1	Y	Y	PF, dust/debris on vents
Teacher's Dining Room	881	ND	71	55	7	2	Y	Y	Y	Ceiling AC
201	710	ND	74	50	7	18	Y	Y	Y	Area rug, window AC, PF, items on/front of UV
202	524	ND	75	53	6	0	Y	Y	Y	Room used occasionally, PF
221	464	ND	75	53	6	0	Y	Y	Y	

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								Intake	Exhaust	
222	557	ND	76	51	7	18	Y, open	Y	Y	
223	516	ND	76	54	6	0	Y, open	Y	Y	
224	447	ND	75	48	6	18	Y, open	Y	Y	
225	516	ND	76	57	8	0	Y, open	Y	Y	
226	432	ND	75	48	5	0	Y	Y	Y	TB
231	510	ND	75	54	7	0	Y	Y	Y	
234	495	ND	75	51	7	0	Y, open	Y	Y	TB
251	514	ND	75	47	5	19	Y, open	Y	Y	
252	580	ND	75	52	8	20	Y/2	Y	Y	PF, DO, area rug
Science	524	ND	75	53	8	0	Y	Y	Y	Shrubs in close proximity to UV air intakes

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								Intake	Exhaust	
Children's Lobby	481	ND	76	51	8	0	N	N	N	4 WD CT
Gym	450	ND	76	47	6	25	Y	Y	Y	

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